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COOLED GAS TURBINE VANES

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This invention relates to guide vanes for a turbine and the like. More specifically, this invention relates to an inlet guide vane ring for a turbine having a closed heat transfer circuit extending from the guide vanes to the compressor discharge area of the gas turbine to cool the vanes in the vane ring.

In present day gas turbine designs, the temperature level at which the turbine section is capable of operating is a limiting factor determining the power rating of the engine. Therefore, one of the easiest ways to increase the power output of a given gas turbine is to increase the operating temperature of the turbine section. Since the inlet guide vanes of the gas turbine are adjacent the downstream end of the combustion section and are, therefore, subjected to the highest temperatures in the turbine section, they become a critical point when the turbine section operating temperature is raised. With the metallurgical temperature limitations placed on today's designs, it becomes feasible to increase the turbine operating temperature only by providing some means of cooling the inlet guide vanes to maintain their temperature within these limits.

Previous cooling systems for the guide vane have included open circuits where compressor discharge air is bled off, flowed through the vanes for cooling and then dumped into the exhaust gas stream. Closed circuits wherein a heat transfer medium is evaporated in the turbine inlet guide vanes and carried upstream where the heat transfer medium is condensed transferring heat to the compressor inlet air has also been used. In the closed system, it is normally necessary to provide pumps in order to circulate the heat transfer medium and usually control, pressure relief valves, and a pump bypass circuit also accompanying the pump and the resulting system becomes highly complicated and unduly burdensome. This invention is directed toward providing a cooling system for the turbine guide vane ring which is of the closed circuit type but yet the system is not highly complicated and unduly burdensome. This system is also designed to transfer the heat to compressor discharge air so as to yield a two-fold benefit. First, the vanes are cooled efficiently. Secondly the heat is transferred so as to give a regenerative effect to the compressor discharge air.

It is an object of this invention to provide a guide vane ring having a closed circuit cooling system which is simple, uncomplicated and comprises a minimum of parts.

Another object of this invention is to provide a guide vane ring having a closed circuit cooling system which does not require a pump, valves or other moving parts to circulate the heat transfer medium.

Another object is to provide a guide vane ring having a closed circuit cooling system which cools the vanes efficiently without degrading the engine's performance.

Other objects and advantages of the invention will hereinafter become more fully apparent from the following description of the annexed drawings, which illustrate a preferred embodiment, and wherein:

FIGURE 1 is a longitudinal section of a gas turbine engine which includes a closed circuit cooling system for the turbine inlet guide vane ring in accordance with this invention.

FIGURE 2 is a cross section taken along the line 2—2 of FIGURE 1 and looking in the direction of the arrows.

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FIGURE 3 is an enlarged view of a portion of FIGURE 1 showing a single guide vane in detail.

FIGURE 4 is a cross section taken along the line 4—4 of FIGURE 3 and looking in the direction of the arrows.

FIGURE 5 is a cross section taken along the line 5—5 of FIGURE 3 and looking in the direction of the arrows.

FIGURE 6 is a cross section taken along the line 6—6 of FIGURE 3 and looking in the direction of the arrows.

FIGURE 7 is a schematic showing the principle of operation of the closed heat transfer circuit used to cool an inlet guide vane such as the one shown in FIGURE 3.

Referring now to FIGURE 1, there is shown a gas turbine engine indicated generally at 10. The gas turbine engine 10 comprises a compressor section 12, diffuser section 14, combustor section 16, turbine section 18, and exhaust section 20. More specifically, the compressor section 12 comprises a cylindrical housing 22 having a plurality of axial compressor stages 24 rotatably mounted therein with guide vane rings 26 mounted between the rotor stages 24. A cylindrical housing 28 extends from the compressor section 12 to the turbine section 18 and houses shaft 30 which is connected to turbine wheels 34 at its downstream end. Struts 36 support the forward end of housing 28 while the rear end is supported by an annular wall 37. The annular wall 37 in turn is strut supported (not shown). The compressor rotors 24 are rim connected and secured axially by a tie bolt 32 to form a drum type rotor with the downstream rotor being connected to shaft 30 to receive torque from the turbine wheels 34. The forward end of the compressor rotor drives a gear box (not shown). Guide vane rings 38 are provided between the turbine rotor 34 and at the inlet of the turbine section 18. The exhaust section 20 is seen to merely comprise an outer circular circuit casing 50 with a tailcone 52 mounted centrally within it to form an exhaust passage 54.

Returning to the diffuser section 14, the forward end of the housing 28 is bell-shaped and forms a diverging annular passage or diffuser 42 with the housing of the compressor section 14. The combustion section 16 is shown as having six circumferentially spaced combustion cans 44 disposed radially between the housing 28 and the outer casing 46 of the combustion section 16. Fuel nozzles 48 mounted in the diffuser casing extend into the forward ends of the combustion cans 44.

Focusing our attention now on the turbine section 18 and the inlet guide ring in particular, it is seen to include a number of vanes 40. Tubes 54 extend from the outer ends of the inlet guide vanes 40 upstream through the combustor section 16. Radially the tubes 54 are located between the combustor cans 44 and the casing 46. The tubes 54 are closed at their upstream ends which terminate adjacent the compressor section 12 where they are exposed to cool compressor discharge air. The flow of the compressor discharge air over the end of the tubes 54 before it enters the combustor cans 44 is indicated in FIGURE 1 by arrows. As shown in FIGURE 2, there are 46 tubes 54, one being provided for each vane 40 in the inlet guide vane ring.

Referring now to FIGURE 3, a single inlet guide vane 40 is shown in detail. As is evident from the cross section, the vane 40 extends between inner and outer shrouds 41 and 43, respectively. The shrouds 41 and 43 are contiguous with the walls 45 which define the turbine inlet passage 47. The guide vane 40 is hollow providing an inner chamber 56. The chamber 56 is in communication with the bore 60 of the closed tube 54. A porous structure 58 is disposed in the chamber 56 adjacent the inner walls of the guide vane 40. The porous structure 58 continues through the transition portion 62 between the vane 40 and the tube 54 and into the tube 54. The cross sec-